CHAPTER 4

HYDRAULIC STRUCTURES

4–1. Manholes and junction boxes. Drainage systems require a variety of appurtenances to assure proper operations. Most numerous appurtenances are manholes and junction boxes. Manholes and junction boxes are generally constructed of any suitable materials such as brick, concrete block, reinforced concrete, precast reinforced-concrete sections, or preformed corrugated metal sections. Manholes are located at intersections, changes in alignment or grade, and at intermediate joints in the system up to every 500 feet. Junction boxes for large pipes are located as necessary to assure proper operation of the drainage system. Inside dimensions of manholes will not be less than 2.5 feet. Inside dimensions of junction boxes will provide for not less than 3 inches of wall on either side of the outside diameter of the largest pipes involved. Manhole frames and cover will be provided as required; rounded manhole and box covers are preferred to square covers. Slab top covers will be provided for large manholes and junction boxes too shallow to permit corbeling of the upper part of the structure. A typical large box drain cover is shown in figure 3-5, TM 5-820-3/AFM 88-5, Chapter 3. Fixed ladders will be provided depending on the depth of the structures. Access to manhole and junction boxes without fixed ladders will be by portable ladders. Manhole and junction box design will insure minimum hydraulic losses through them. Typical manhole and junction box construction is shown in figures 4-1 through 4-3.

4–2. Detention pond storage. Hydrologic studies of the drainage area will reveal if detention ponds are required. Temporary storage or pending may be required if the outflow from a drainage area is limited by the capacity of the drainage system serving a given area. A full discussion of temporary storage or ponding design will be found in appendix B, TM 5-820-l/AFM 88-5, Chapter 1. Pending areas should be designed to avoid creation of a facility that would be unsightly, difficult to maintain, or a menace to health or safety.

4-3. Outlet energy dissipators.

a. Most drainage systems are designed to operate under normal free outfall conditions. Tailwater conditions are generally absent. However, it is possible for a discharge resulting from a drainage system to possess kinetic energy in excess of that which normally occurs in waterways. To reduce the kinetic energy, and thereby reduce downstream scour, outfalls may sometimes be required to reduce streambed scour. Scour may occur in the streambed if discharge velocities exceed the values listed in table 4-1. These values are to be used only as guides; studies of local materials must be made prior to a decision to install energy dissipation devices. Protection against scour may be provided by plain outlets, transitions and stilling basins. Plain outlets provide no protective works and depend on natural material to resist erosion. Transitions provide little or no dissipation of energy themselves, but by spreading the effluent jet to approximately the flow cross-section of the natural channel, the energy is greatly reduced prior to releasing the effluent into the outlet channel. Stilling basins dissipate the high kinetic energy of flow by a hydraulic jump or other means. Riprap may be required at any of the three types of outfalls.

(1) *Plain type.*

(*a*) If the discharge channel is in rock or a material highly resistant to erosion, no special erosion protection is required. However, since flow from the culvert will spread with a resultant drop

Table 4-1. Maximum Permissible Mean Velocities to Prevent Scour

Material	*Maximum Permissible Mean Velocity*
Uniform graded sand and cohesionless silts	1.5 fps
Well-graded sand	2.5 fps
Silty sand	3.0 fps
Clay	4.0 fps
Gravel	6.0 fps

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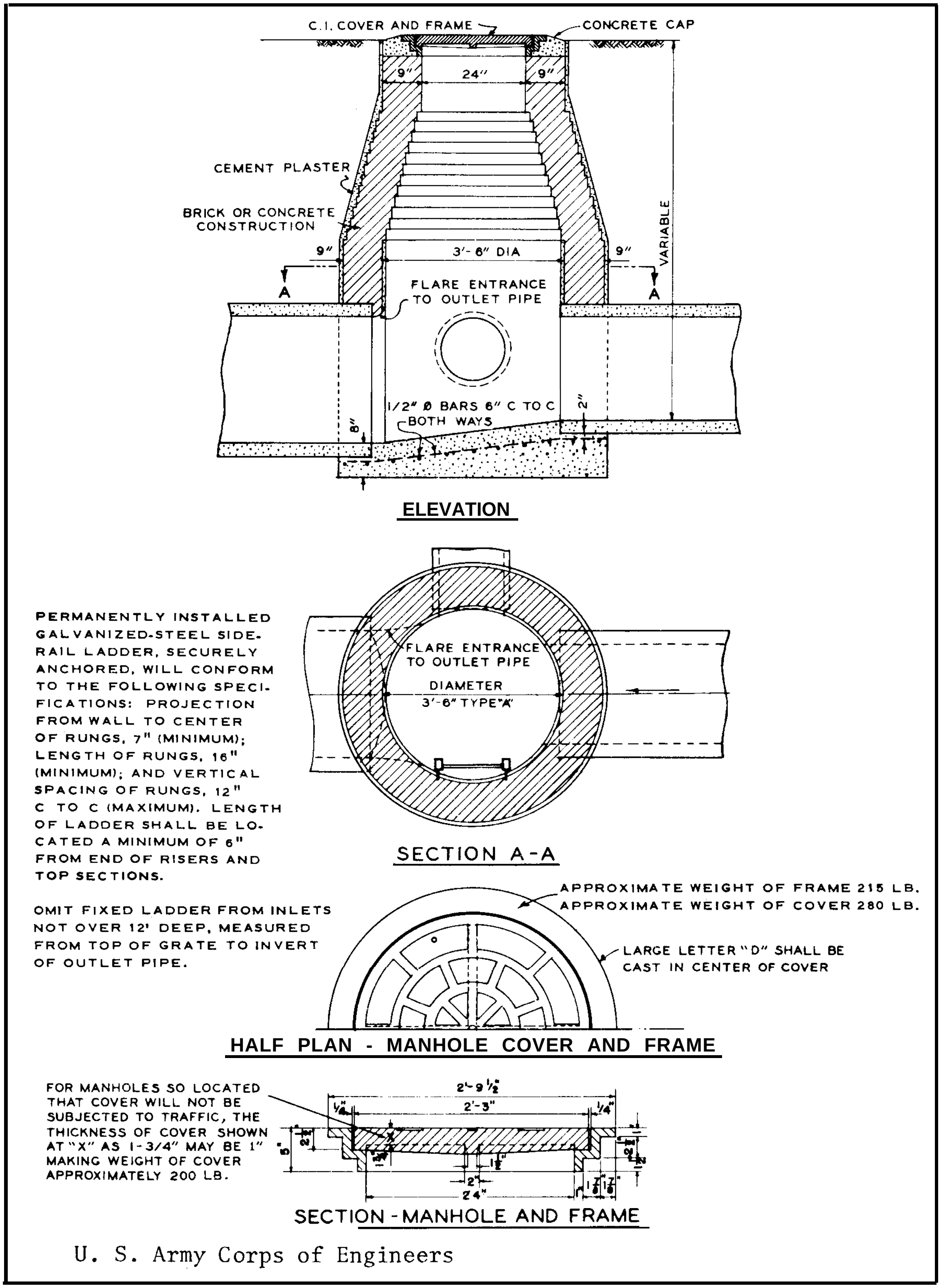
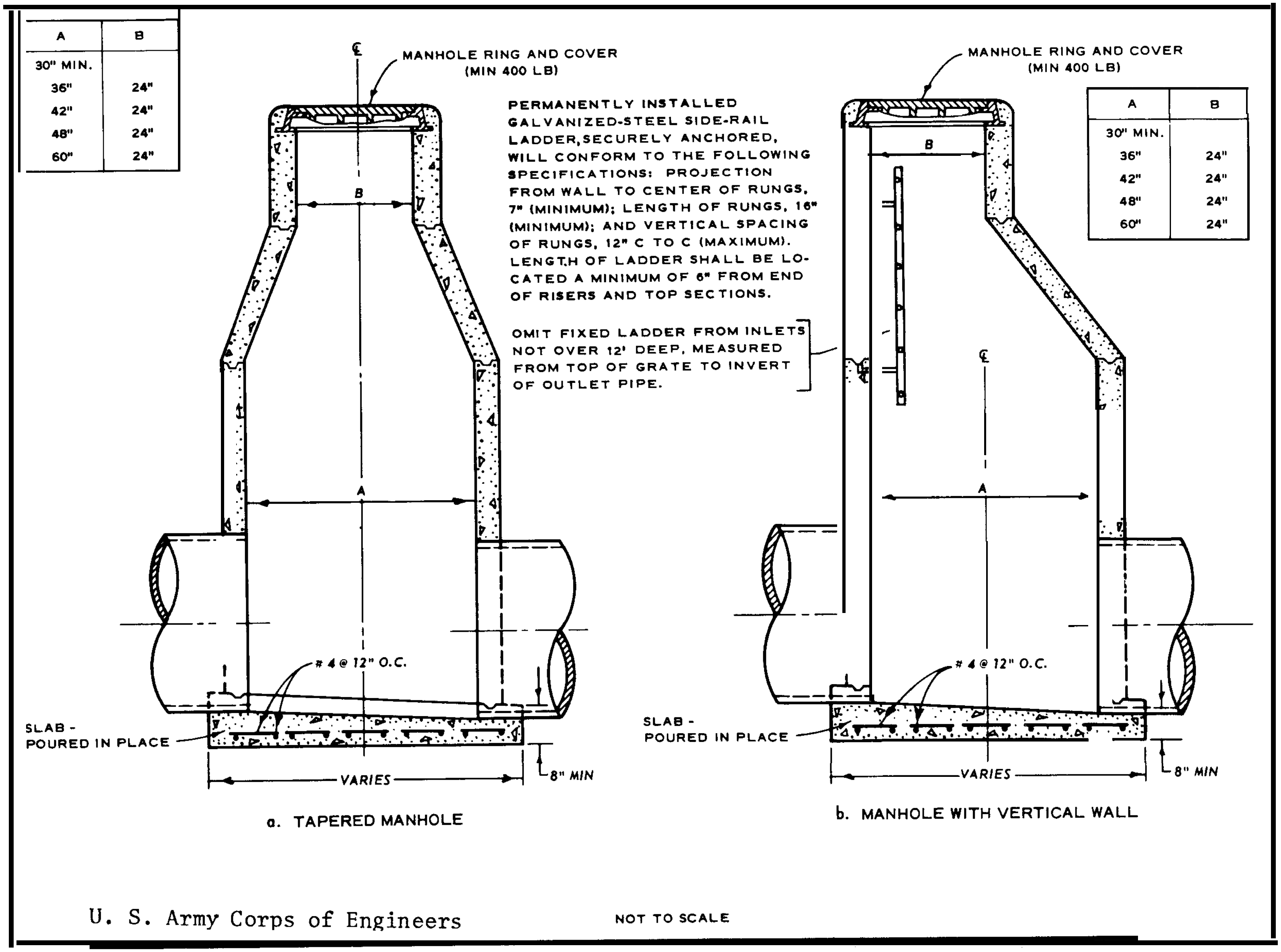


Figure 4–1. Standard storm drain manhole.



A	B
30" MIN.	
36"	24"
42"	24"
48"	24"
60"	24"

Figure 4–2. Standard precast manholes.

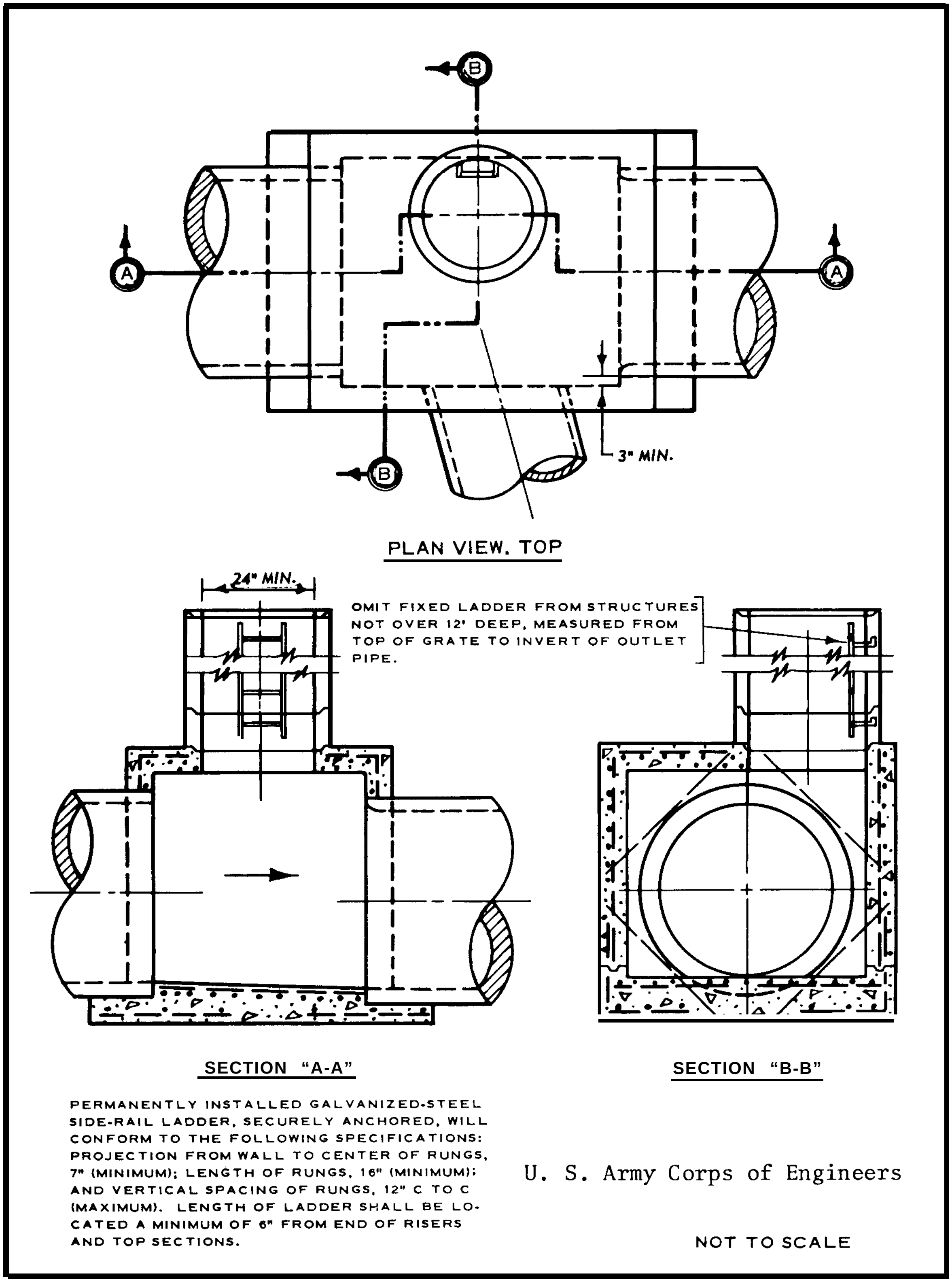


Figure 4–3. Junction details for large pipes.

in water surface and increase in velocity, this type of outlet should be used without riprap only if the material in the outlet channel can withstand velocities about 1.5 times the velocity in the culvert. At such an outlet, side erosion due to eddy action or turbulence is more likely to prove troublesome than is bottom scour.

(b) Cantilevered culvert outlets may be used to discharge a free-falling jet onto the bed of the outlet channel. A plunge pool will be developed, the depth and size of which will depend on the energy of the falling jet at the tailwater and the erodibility of the bed material.

(2) *Transition type.* Endwalls (outfall headwalls) serve the dual purpose of retaining the embankment and limiting the outlet transition boundary. Erosion of embankment toes usually can be traced to eddy attack at the ends of such walls. A flared transition is very effective, if proportioned so that eddies induced by the effluent jet do not continue beyond the end of the wall or overtop a sloped wall. As a guide, it is suggested that the product of velocity and flare angle should not exceed 150. That is, if effluent velocity is 5 feet per second each wingwall may flare 30 degrees; but if velocity is 15 feet per second, the flare should not exceed 10 degrees. Unless wingwalls can be anchored on a stable foundation, a paved apron between the wingwalls is required. Special care must be taken in design of the structure to preclude undermining. A newly excavated channel may be expected to degrade, and proper allowance for this action should be included in establishing the apron elevation and depth of cutoff wall. Warped endwalls provide excellent transitions in that they result in the release of flow in a trapezoidal section, which generally approximates the cross section of the outlet channel. If a warped transition is placed at the end of a curved section below a culvert, the transition is made at the end of the curved section to minimize the possibility of overtopping due to superelevation of the water surface. A paved apron is required with warped endwalls. Riprap usually is required at the end of a transition-type outlet.

(3) *Stilling basins.* A detailed discussion of stilling basins for circular storm drain outlets can be found in chapter 7, TM 5–820–3.

b. Improved channels, especially the paved ones, commonly carry water at velocities higher than those prevailing in the natural channels into which they discharge. Often riprap will suffice for dissipation of excess energy. A cutoff wall may be required at the end of a paved channel to preclude undermining. In extreme cases a flared transition, stilling basin, or impact device may be required.

4–4. Drop structures and check dams. Drop structures and check dams are designed to check channel erosion by controlling the effective gradient, and to provide for abrupt changes in channel gradient by means of a vertical drop. The structures also provide satisfactory means for discharging accumulated surface runoff over fills with heights not exceeding about 5 feet and over embankments higher than 5 feet provided the end sill of the drop structure extends beyond the toe of the embankment. The check dam is a modification of the drop structure used for erosion control in small channels where a less elaborate structure is permissible. Pertinent design features are covered in chapter 5, TM 5–820–3/AFM 88–5, Chapter 3.

4–5. Miscellaneous structures.

a. A chute is a steep open channel which provides a method of discharging accumulated surface runoff over fills and embankments. A typical design is included in chapter 6, TM 5–820–3/AFM 88–5, Chapter 3.

b. When a conduit or channel passes through or beneath a security fence and forms an opening greater than 96 square inches in area a security barrier must be installed. Barriers are usually of bars, grillwork, or chain-link screens, Parallel bars used to prevent access will be spaced not more than 6 inches apart, and will be of sufficient strength to preclude bending by hand after assembly.

(1) Where fences enclose maximum security areas such as exclusion and restricted areas, drainage channels, ditches, and equalizers will, wherever possible, be carried under the fence in one or more pipes having an internal diameter of not more than 10 inches. Where the volume of flow is such that the multipipe arrangement is not feasible, the conduit or culvert will be protected by a security grill composed of 3/4-inch-diameter rods or 1/2-inch bars spaced not more than 6 inches on center, set and welded in an internal frame. Where rods or bars exceed 18 inches in length, suitable spacer bars will be provided at not more than 18 inches on center, welded at all intersections. Security grills will be located inside the protected area. Where the grill is on the downstream end of the culvert, the grill will be hinged to facilitate cleaning and provided with a latch and padlock, and a debris catcher will be installed in the upstream end of the conduit or culvert. Elsewhere the grill will be permanently attached to the cul-

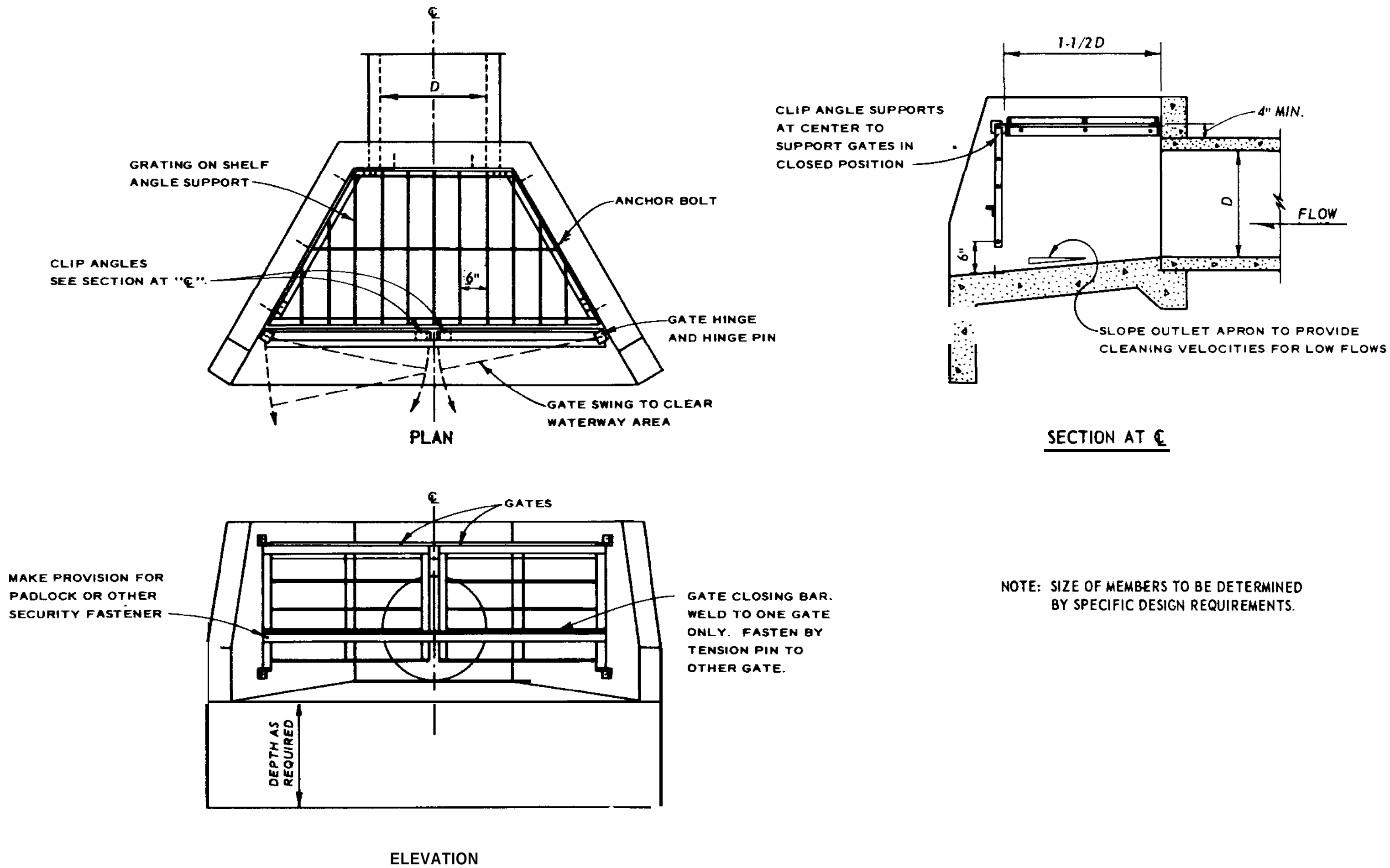


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Figure 4–4. Outlet security barrier.

vert. Security regulations normally require the guard to inspect such grills at least once every shift. For culverts in rough terrain, steps will be provided to the grill to facilitate inspection and cleaning.

(2) For culverts and storm drains, barriers at the intakes would be preferable to barriers at the outlets because of the relative ease of debris removal. However, barriers at the outfalls are usually essential; in these cases consideration should be given to placing debris interceptors at the inlets. Bars constituting a barrier should be placed in a horizontal position, and the number of vertical members should be limited in order to minimize clogging; the total clear area should be at least twice the area of the conduit or larger under severe debris conditions. For large conduits an elaborate cagelike structure may be required. Provisions to facilitate cleaning during or immediately after heavy runoff should be made. Figure 4–4 shows a typical barrier for the outlet of a pipe drain. It will be noted that a 6-inch underclearance is provided to permit passage of normal bedload material, and that the apron between the conduit outlet and the barrier is placed on a slope to minimize deposition of sediment on the apron during ordinary flow. Erosion protection, where required, is placed immediately downstream from the barrier.

(3) If manholes must be located in the immediate vicinity of a security fence their covers must be so fastened as to prevent unauthorized opening.

(4) Open channels may present special problems due to the relatively large size of the waterway and the possible requirements for passage of large floating debris. For such channels a barrier should be provided that can be unfastened and opened or lifted during periods of heavy runoff or when clogged. The barrier is hinged at the top and an empty tank is welded to it at the bottom to serve as a float. Open channels or swales which drain relatively small areas and whose flows carry only minor quantities of debris may be secured merely by extending the fence down to a concrete sill set into the sides and across the bottom of the channel.